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Fighting Black Stem Rust of Grain by Eradicating the Barberry



STATE DEPARTMENT OF AGRICULTURE

Division of Insect and Plant Disease Control
Madison, Wisconsin

AND

AGRICULTURAL EXPERIMENT STATION OF THE
UNIVERSITY OF WISCONSIN

Madison
Cooperating

The cities and villages of Wisconsin have been surveyed for barberry and practically all bushes have been pulled out. Resurveys are necessary because suckers start readily from the broken roots. Furthermore, the surveys have shown that the barberry is much more widely distributed than was first thought, and in several instances it has escaped into pastures and woodlots and has multiplied into the millions. While complete eradication, at the present rate of progress, will require a number of years, it is thoroughly worth while.

Intensive farm-to-farm surveys are being conducted in the southern half of the state at the present time. This work is correlated with similar work in northern Illinois, Iowa and Minnesota so as to make as large an area as possible that is "barberry-clean." Many hedges and individual barberry bushes have been located in this way that otherwise would have escaped attention and continued to be a menace to the grain-growing interests.

At the end of 1922, there had been found in Wisconsin 3,354,155 dangerous barberry bushes of which 2,788,936 had been removed. More than half of all the barberries found in the 13 states working under the eradication plan have been located in Wisconsin, showing that this state is a large center of infection and indicating the necessity of continued close cooperation between farmer, townsman, and inspectors to make the campaign the success that its importance merits.

The United States Department of Agriculture, the State Department of Agriculture and the College of Agriculture are cooperating in the barberry eradication, the federal government having supplied the major portion of funds to defray field expenses. Five publications on barberry eradication have been issued by the United States Department of Agriculture; namely, Farmers' Bulletin, 1058, entitled "Destroy the Common Barberry;" Department Circular 188, entitled "Progress of Barberry Eradication;" Separate from Yearbook No. 796, entitled "The Black Stem Rust and the Barberry;" Department Circular 269 entitled "Barberry Eradication Prevents Black Rust in Western Europe;" and Department Circular 268 entitled "Kill the Common Barberry With Chemicals." These may be had free on request from the Secretary of Agriculture, Washington, D. C., or Commissioner of Agriculture, State Capitol, Madison, Wis.

Fighting Black Stem Rust of Grains By Eradicating the Barberry

By

NOEL F. THOMPSON AND JAMES G. DICKSON*

The black stem rust of wheat, rye, oats and barley is being controlled in Wisconsin by eradicating the common barberry (*Berberis vulgaris* L.). Information gained since 1918 has shown that the early stem rust outbreaks each year are due to a general spread of rust from the barberry to these grains early in the spring. The spores blown in from other more distant areas do not develop rust on these grains until after the danger of damage from rust has passed. In other words, the barberry in Wisconsin has been found to be the source of early stem rust outbreaks on wheat, rye, oats and barley.

Commendable progress has been made in destroying the dangerous, common barberry in Wisconsin, but many bushes still remain. The surveys made since 1918 have shown that the barberry was much more widely distributed in Wisconsin than was at first thought possible. In many localities the shrub has escaped from cultivation and is growing wild in pastures and woodlots. It is necessary, therefore, that if effective control of stem rust is to be obtained, the campaign for barberry eradication must be continued until the escaped as well as cultivated bushes are destroyed.

Heavy Losses Caused by Black Stem Rust

Black stem rust of wheat, rye, oats, and barley causes heavy losses of these crops each year. It is a disease produced by a minute plant called a fungus. This fungus grows within the grain plants in a manner somewhat similar to the way the grain plants grow in the soil. Growing in this way, the fungus takes its food and moisture from the grain plant on which it is growing, thus robbing the plant of the food which should normally go to the head to form plump, heavy kernels. In addition, the rust fungus growing in the plant breaks the outer layers of the stems and leaves and allows a large amount of water to escape. (Fig. 1.) Badly rusted plants, as is well known, produce greatly shrunken or shrivelled grain of light weight and poor quality. (Fig. 2.)

While it is difficult to estimate the losses caused in this way by black stem rust, yet the annual reduction in yield from this cause is

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very great and in years when severe and widespread rust epidemics occur the entire crop is damaged. In the United States, the reduction in yield of wheat alone varies from 800,000 bushels as estimated for 1918 to 180,000,000 bushels as estimated for 1916. The estimated



FIG. 1.—THE STEM RUST SPLITS THE SURFACE OF THE STEM AND LEAVES

The stem rust appears on the leaves and stems of barley, oats, wheat, rye and some grasses.

average loss of wheat for the five years from 1916 to 1920, inclusive, is about 64,000,000 bushels each year.

While Wisconsin is not one of the chief wheat-producing states, the total production of small grains places Wisconsin high in the list of grain-producing states. For example, in 1922 Wisconsin produced 102,000,000 bushels of oats, 14,000,000 bushels of barley, 7,000,000 bushels of rye and 3,000,000 bushels of wheat, a total of 126,000,000 bushels of small grains. As the losses from stem rust on all of these cereals is high in Wisconsin, the state is vitally interested in the control of stem rust.



FIG. 2.—THE STEM RUST CAUSES SMALL HEADS AND BADLY SHRIVELED GRAIN

The wheat heads shown at A were collected near a barberry bush where the rust was very heavy. The heads are small, the straw is poor, and the grain is light and shriveled. The head shown at B was from a portion of the field free from rust. The heads are large, the straw is clean, and the grain plump and heavy.

Black Stem Rust Has Strange Life Story

The development of black stem rust makes a very interesting story. The rust usually makes its appearance on the grain about the last of May in Wisconsin, as a brick-red pustule or spot on the stem or leaf. (Fig. 1.) A close examination of this red pustule shows it to be filled with a fine powder—the spores or “seeds” of the tiny rust plant. If these spores are shaken or blown by the wind to other similar grains

and are given sufficient moisture and warmth they grow and develop rust on those plants also. The growth of the rust plant is so rapid that it takes only a week or ten days from the time the spores fall on one of the grains until new spores are produced, as evidenced by the

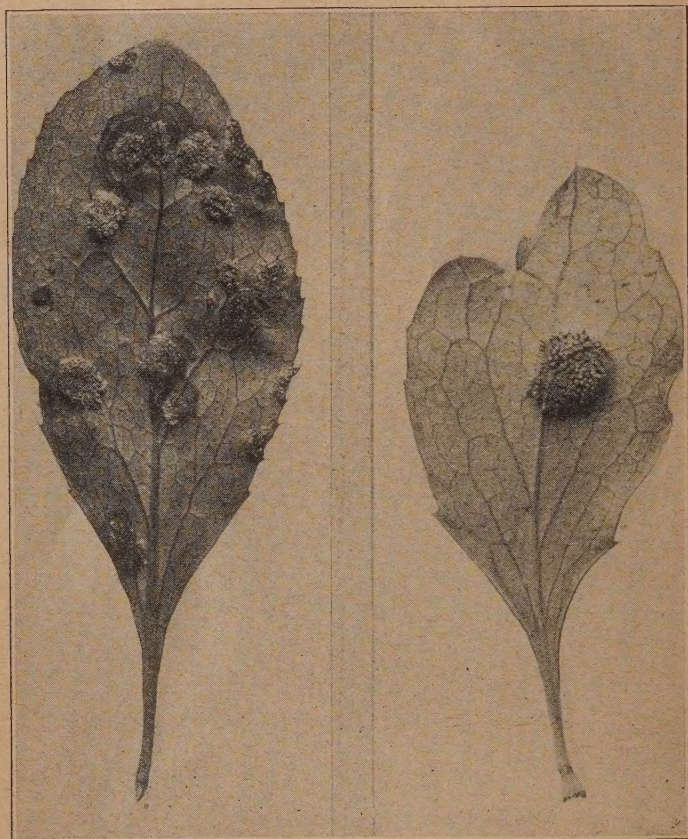


FIG. 3.—THE STEM RUST FORMS CLUSTER CUPS ON THE LEAVES OF THE COMMON BARBERRY

The cluster cups of the spring stage of stem rust appear on the under surface of the common barberry leaves and spread spores to the surrounding grains and grasses. The large cluster cup on the right is magnified in Fig. 6.

production of the red pustules. This process may be repeated over and over again as long as the grains on which the rust plant grows remain green and the weather is favorable. Enormous numbers of these spores are produced. The red dust seen occasionally during the

harvesting of the grain is composed entirely of these spores of the rust fungus, and each spore is capable of spreading the disease.

When the grain begins to ripen, a change takes place in the rust. Red spores are produced no longer, but in their place heavy black spores are formed. (Fig. 1.) These black spores differ from the red spores in both color and habit, for they cannot produce rust on other grains but serve to carry the rust plant over the winter. They readily live through conditions of cold and wet which the red spores cannot withstand. It is only under the most favorable conditions that any of the red spores are able to survive the winters in Wisconsin. Indeed, there are records of only two such cases. So if the rust plant is to survive the winter it must depend on the black spores. These germinate in the spring on the stubble or old straw and produce tiny color-

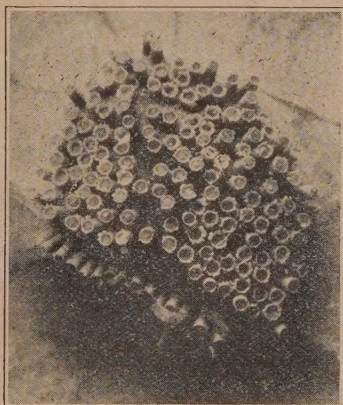


FIG. 4.—CLUSTER CUP OF THE STEM RUST ON BARBERRY HIGHLY MAGNIFIED

Each little cup contains spores enough to sow stem rust on an acre of grain. There are spores enough on the whole cluster cup to spread rust over a 40-acre field.

less spores which are blown about by the wind. If these fall on growing grain, they are unable to produce rust and soon die. They also die if they fall on the soil, but if they light on a common barberry and gain entrance to its young growing parts, they live and produce thrifty little rust plants.

Millions of the black rust spores live over the winter and each produces several of the tiny colorless spores in the spring, but all of them die except the few which happen to fall on a common barberry and penetrate it. On the barberry leaves yellow patches are formed by the rust (Fig. 3) and from these patches, (Fig. 4 and 5) yellow spores spread the rust back again to the grain, producing the red rust pustules on the stems and leaves. This completes the life story of the black stem rust.

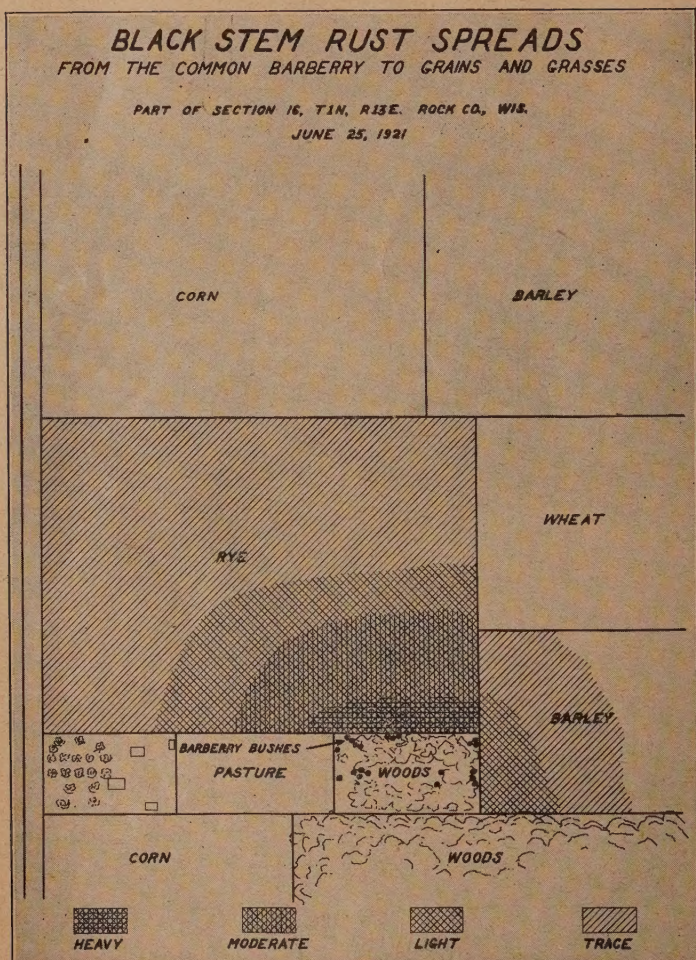


FIG. 5.—SPREAD OF RUST FROM THE BARBERRY

Map showing the spread of black stem rust from common barberry bushes growing wild in a pasture and wood lot on Section 16, Township 1 N, Range 13 E, Rock County, Wisconsin, in 1921. The density of shading shows the severity of the rust infection on rye and barley. Notice that the wheat was not rusted indicating that only the rye-barley strain of rust was present.

Thus do we see that there are three different forms in which we may find the black stem rust. During the early part of the summer we have the red form on the grain. This spreads the rust from one grain plant to the next. As the grain ripens the black form develops and this is able to live through the winter on the stubble and straw and to infect the barberry in the spring, producing the third or yellow form of the rust. From the barberry the rust returns to the grain only in the spring.

Different Strains of Stem Rust

The black stem rust of all the grains is caused by the same species of rust fungus, which is named *Puccinia graminis*. There are, however, several so-called specialized strains of the fungus each capable of attacking only a limited number of grains and grasses. For example, the stem rust strain of rye, barley, quack grass, and certain other grasses cannot attack wheat or oats. (Fig. 5 and 7.) The stem rust strain on wheat attacks wheat, barley, squirrel-tail grass, and certain other grasses, but cannot attack rye or oats. Similarly, the stem rust strain on oats attacks oats and certain grasses but cannot attack rye, wheat, or barley. Barley is the only grain that is subject to the attacks of more than one of these stem rust strains, for both the rye and wheat strains may attack barley. On the other hand, barley is the only grain which does not have a stem rust strain specialized chiefly on itself.

All of these various specialized strains of black stem rust can infect the common barberry in the spring by means of their black spores. And then in turn, each strain can spread from the barberry back to the same grain or grains and grasses to which it is specialized. That is, the specialization remains the same, even after infecting the barberry; so that if the rust on the barberry came from black spores produced on oats it could return to oats but could not cause rust on wheat or rye. This explains many cases where rust has attacked a field of one kind of grain and not neighboring fields of other cereals.

There Are Two Types of Rust on Grains

In addition to black stem rust, or "black rust" as it is frequently called, there also are leaf rusts which occur on the various grains. These leaf rusts are often confused with black stem rust. They are, however, entirely different and are caused by other species of rust fungi. These leaf rust fungi do not attack the barberry nor do they usually cause serious losses of grains in Wisconsin.

Leaf rusts usually can be distinguished from black stem rust by their position on the grain plant and by the size and shape of the spots they produce. The leaf rusts occur only on the leaves and leaf sheaths of the grain, and the spots produced are quite small and usually round. Early in the season these spots are filled with an orange-yellow, powdery substance, but later in the summer they may appear grayish-black. The black stem rust, on the other hand, develops on both the leaves and the stem of the grain. The spots are long and filled with

a brick red powder or, later in the summer, with a black powder. The skin of the grain plant breaks and curls back from the rust spot. This is the rust which causes the most severe damage to the grain and also attacks the common barberry.

Relation of the Common Barberry to Stem Rust in Wisconsin

The life story of the black stem rust as just outlined in the previous paragraphs varies considerably in different sections of the United

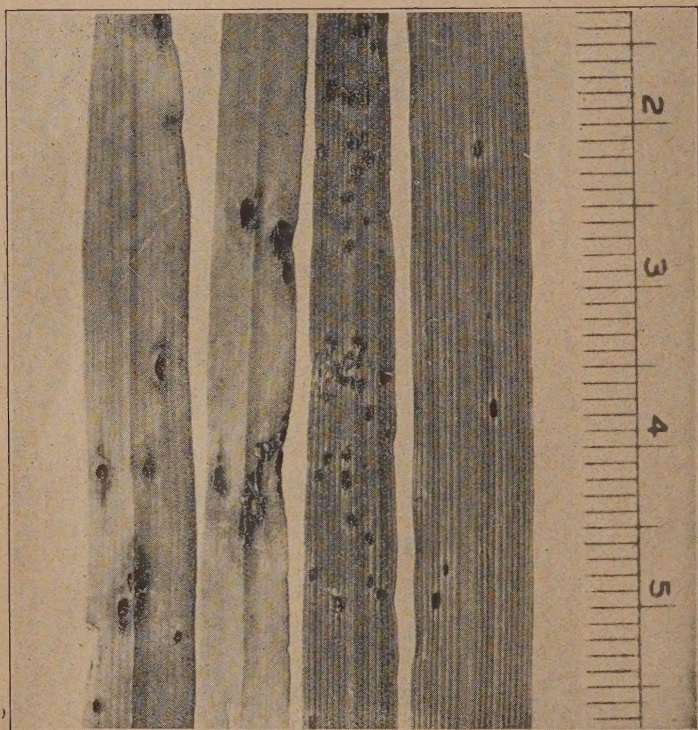


FIG. 6.—THE STEM RUST AND LEAF RUST ARE DIFFERENT

The stem rust on the leaves of winter rye (left) causes long lesions and splits the surface of the leaves. The leaf rust (right) causes small round lesions and does not split the leaf surface.

States. In Wisconsin and throughout the central and north-central sections of the United States, the red rust spores or summer spores are killed during the winter and early spring by the cold weather and by freezing and thawing, thus the rust lives over chiefly in the black rust stage and must go through the barberry to again rust the grains.

Thousands of samples of rust collected in the field in Wisconsin and in the adjoining states have been tested for germination during the winter and spring each year from 1918 to 1922. While these red rust spores germinate and are capable of producing rust on the grains until late in the winter, they generally die during late winter, and early spring, or become too weak to rust the grain plants. The average of the germination tests, given in Table I, shows the limited amount of germination that occurs as spring and the new growing season approach. Though apparently each year some of the red rust spores lived over winter in a few locations, no new rust developed at any of these stations during the following spring. Quantities of the red rust spores were taken in from out-of-doors during the late winter and sown on the same grains growing in the greenhouse but produced no rust. Therefore, while some of these spores germinated, they were evidently too weak to produce rust on the new spring plants.

TABLE I.—THE AVERAGE PERCENTAGE GERMINATION OF THE RED RUST SPORES OF THE BLACK STEM RUST.

Plant on which rust occurred	Average percentage germination of red rust spores for each month						
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Wheat.....	24.2	12.8	2.0	0.0	0.1	0.0	0.0
Rye.....	32.9	1.7	1.7	0.0	0.2	0.0	0.1
Oats.....	30.2	9.3	1.9	0.6	0.1	1.1	0.1
Average.....	29.1	7.9	1.9	0.2	0.1	0.4	0.1

While a few of the red rust spores in protected places live through the winter especially during very mild seasons, the majority of these spores die fairly early in the winter, October and November. In addition to the red rust spores being killed by the winter exposures, the rust plant in the wheat leaves dies as the wheat leaves attacked by stem rust rot very easily under the snow during the winter months.

In only two instances in Wisconsin has rust been found which had spread the following spring from the red rust stage living over winter. The spread of rust from these plants has been very slow and decidedly limited. For example, a field of winter wheat on the university farm was heavily rusted with the red rust stage of black stem rust late in the fall of 1919. Of the thousands of wheat plants heavily rusted during the fall, only one plant was found in a sheltered place in the field in the spring of 1920 on which the red rust had lived over winter. This plant was found early in April while the barberry leaves were yet in the bud. The plant was marked and all adjoining plants carefully watched for the spread of rust. The last week in April new rust was found on the newer leaves of this plant and on three plants in contact with this plant. On May 30, when the rust was spreading in large quantities from the common barberry to the adjoining grain fields, no

new rust had developed on these plants. At heading time, the rust had spread from this one plant to the lower leaves of some of the plants four to eight drill rows away and at harvest the rust had spread scatteringly over one edge of a late planting of Marquis wheat but too late to do any damage to either the winter or spring wheat.

The red rust which over-winters is always close to the ground on the fall leaves and is protected by the growth above it. On the other hand, the rust which develops on the barberry is out where the wind catches the light spores and spreads them long distances to the grains and grasses. Thus the spread of rust in the first case is near the ground and limited while in the latter case the rust spores from the barberry are carried long distances by the wind and settle down on the tops of the growing grains.

The rust develops on the barberry in Wisconsin in early May and begins spreading rust to the grains and grasses soon after the middle of May. The following table gives the dates at which the barberry has rusted, the dates rust spread to grains and grasses, and the general stage of development of winter and spring grains at the date of rusting.

TABLE II.—THE STAGE OF DEVELOPMENT OF GRAINS AND THE DATE OF SPREAD OF RUST FROM THE BARBERRY.

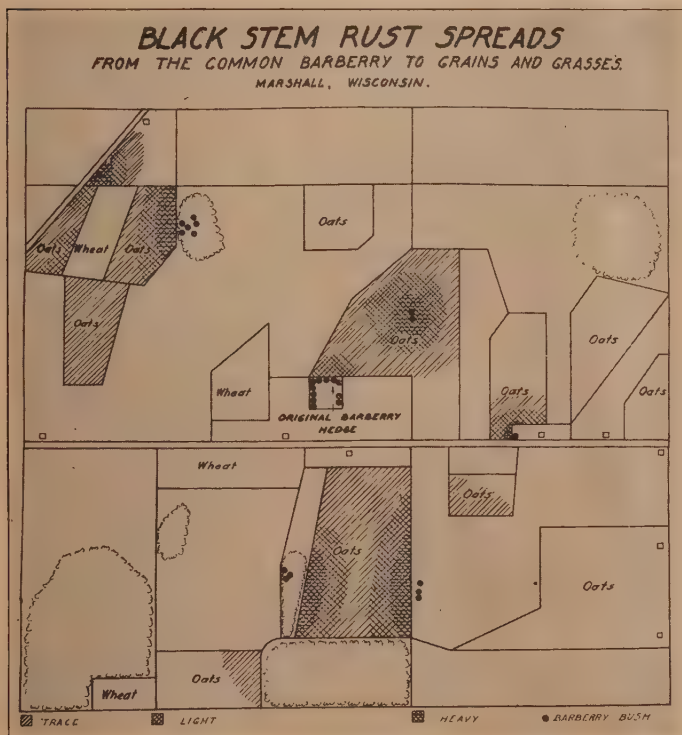
Season	Date barberry rusted	Date rust found on grain	Stage of development of grain	
			Winter	Spring
1918.....	May 11	June 6	Shooting	Tillering
1919.....	May 18	June 10	Heading	Tillering
1920.....	May 23	June 12	Heading	Tillering
1921.....	May 1	May 30	Shooting	Tillering
1922.....	Apr. 29	June 2	Heading	Seedlings

It is evident from the above table that in Wisconsin the barberry is the important factor in the early and general spread of stem rust to the grains. This season for example the barberry was rusted and ready to spread rust to the grains almost before the spring grains were out of the ground or the winter grains had started growing. The barberry was ready to spread rust on May 5 before rust had been reported even in the extreme southern wheat sections.

The barberry spreads the rust over the adjoining grain fields and wild grasses producing an early rust infection which then spreads from plant to plant in the field causing total losses in the vicinity of the bushes and heavy losses over an area of several miles from the bush.

Figure 6 is a map showing the early spring spread of rust from the barberry to winter rye and spring barley. The rust spread from the barberry out over the fields causing a heavy rust attack near the barberries and a light spread over the surrounding fields just previous to the heading of the winter rye. The rust two weeks later had spread from plant to plant and at the time the rye was in the soft dough stage

was bad over the entire field. At this time a light sprinkling of rust was found generally throughout the entire county. Likewise the rust on the barley had spread from field to field causing damage to this crop. The barberry, then, spread the rust to the winter rye in May and ruined the crop in the field adjacent to the bushes; it then spread from field to field over a considerable area but fortunately weather conditions were not favorable for a rust epidemic or this would have



A clear cut example of the influence of the barberry on the development of stem rust was found in LaPorte county, Indiana. Only one barberry planting has been reported in the county and the farmers in this section had been troubled year after year with stem rust. The rust was even so severe in the vicinity of the barberry planting that wheat growing had been abandoned. The county agent working with the farmers cleaned the barberry bushes out of this pasture and killed all of the sprouts. The following spring they planted wheat in the fields adjoining the pasture and watched closely for stem rust. The fields all developed a full crop with no trace of stem rust, whereas in the previous seasons the yields were reduced by over one-half. Wheat has been grown on these fields since and no stem rust has developed. Wisconsin, this season, will have regions entirely free from the barberry which will give the same results.

In the two instances where the rust has been found overwintering on the grains and grasses, the spread of rust has not occurred until in July, which is too late to greatly damage even the late spring grains. The spread of rust from the barberry, on the other hand, has for the past three years occurred before June first, early enough to ruin both winter and spring grains if weather conditions are favorable for a rust epidemic. The eradication of the barberry in Wisconsin, therefore, will check the general spread of rust to the grains and retard all spread until the grain crops are safe from rust. For the grain growers all know that a rust epidemic before or while the kernels are filling means a heavy loss, whereas the same rust epidemic coming ten days later means little or no loss.

The stem rust in Wisconsin overwinters in the black rust stage and then rusting the barberry in the early spring spreads to the grains and grasses. Occasionally however the rust overwinters in the red rust stage on the grains and grasses and in addition it may spread into the northern states from the gulf states where the red rust spores overwinter without great difficulty. While the rust spores are carried long distances by strong northerly winds, especially in the great plains region, the detailed survey the past two seasons has shown conclusively that rust in the northern great plains region and especially in Wisconsin from such a source does not reach the grain crops early enough to cause heavy losses. For example, in the spring of 1921, the barberry in Wisconsin was spreading quantities of stem rust to the adjoining grain fields June 1. At this date no rust occurred in the south, north of the southern boundary of Kansas. The general light spread of stem rust which might have been attributed to the spread of rust from the south did not occur until late in June. Again in 1922 the barberry was spreading rust May fifth, almost before the spring grains were out of the soil and no stem rust had been found north of northern Texas.

While the rust undoubtedly does overwinter in the red rust stage in protected places and under favorable seasonal conditions in Wisconsin; and while it undoubtedly spreads into the northern states from the south as the season advances, the rust in Wisconsin from both of these sources reaches the winter and spring grains too late to cause an epi-



FIG. 8.

THE DANGEROUS BARBERRY

THE HARMLESS BARBERRY

The tall barberry (left) helps to spread stem rust, is dangerous and should be destroyed. The low Japanese barberry (right) is harmless and may be grown.

demic and serious loss even under very favorable weather conditions. The spread of rust from the barberry on the other hand occurs early in the spring each year and results in a general development of stem rust, always damaging the grains near the barberries, and occasionally spreading in epidemic form over the entire state and northwest.

Different Kinds of Barberries

There are many species of barberry. Some are native in certain sections of the United States but fortunately only a few of these species become rusted, and there are no native barberries in Wisconsin or the adjoining states which carry the black stem rust. Not all even of the introduced barberries carry this rust, so it is necessary to distinguish between those that do and those that do not. The varieties that have been most commonly planted are the common green barberry (*Berberis vulgaris*), the common purple barberry (*Berberis vulgaris purpurea*), and the Japanese barberry (*Berberis thunbergii*). (Fig. 8.) Of these three, the first two are equally dangerous as spreaders of stem rust of all the cereals and they should be destroyed. The



FIG. 9.—THE COMMON BARBERRY AND THE JAPANESE BARBERRY, SHOWING THE DIFFERENCES

Leaves: Fairly large, with saw-tooth edges.	Leaves: Rather small, with smooth edges.
Spines: Long, and usually in groups of three.	Spines: Fairly short and usually single.
Berries: In clusters like currants.	Berries: One or two together.

Japanese barberry, on the other hand, does not rust and is entirely harmless. This is fortunate, as it is a beautiful shrub and is largely used in ornamental plantings.

These plants are easily distinguished, as is indicated in Fig. 9. The green and purple varieties are almost identical except that one has green leaves and the other has reddish-purple leaves. As these plants are not native to our state they are not ordinarily found growing wild in the woods but should be looked for among the shrubs planted around houses and on lawns. In a number of places, however, the common barberry has escaped from cultivation in Wisconsin and has spread extensively in pastures and woodlots. If this spread were not being checked by the Barberry Eradication Campaign, it might soon have been as impossible to eradicate the barberry from the state as it would be to eradicate the Canada thistle.

Some other varieties of barberry as well as some varieties of mahonia also carry the black stem rust but, as very few of these have been planted in Wisconsin, it is hardly necessary to describe them. The barberry law covers all such plants and in case any question arises as to the nature of any particular plant it would be well to send a specimen to Madison to the Agricultural Experiment Station or the State Department of Agriculture for identification.

History of the Barberry

Barberry a Native of Asia

The common barberry is neither native to Wisconsin nor to the United States, but is believed to have come originally from western Asia, where it is still found growing wild in the Himalaya mountains. One of the earliest records of this plant is in the Babylonian writings of about 650 B. C., where it is mentioned as being of medicinal value. Like many other Asiatic medicinal plants, it was carried by man wherever civilization advanced and possibly was introduced into Europe in this way. Even during the eighteenth century, it was very highly prized by the doctors of Europe and the alleged virtues of the various portions of the plant are described in detail. When we recall that the medical men of that day had to raise their own plants and make their own drugs to a very large extent we can understand why the barberry came to be planted in every village and town.

During the latter part of the eighteenth century and in the early part of the nineteenth, the common barberry came into favor as a hedge to separate fields. Its rank, rapid growth and its long sharp thorns made it excellent for this purpose. As the bushes became abundant and large crops of berries were produced, the juice of the fruit found a ready use as a beverage and also in the making of jellies and preserves. So, in many places, we find the bushes planted in gardens as are currants and gooseberries.

Introduced Into the United States by Early Settlers

The common barberry seems to have been one of the first plants brought to America by the early New England settlers and there are accounts of the use of barberry jelly as a medicine in the latter part of the seventeenth century. By 1700 it had become firmly established in the New England states, and, since that time, wherever the New Englanders have moved they have taken the barberry with them. As many of the early settlers of Wisconsin were from New England, it is not surprising that their log cabins became the centers for the spread of the barberry in this state.

The Barberry Was Brought to Wisconsin Many Years Ago

One of the earliest plantings of which we have record was on the farm of John Hilton, who patented a half section of land near the city of Madison in 1836. These plants thrived and became wild, spreading

extensively throughout the woods south of Lake Mendota. Another record is of barberries near Baraboo planted by David Wells, who brought them from Vermont in 1856. There are many similar records. Hence, it is evident that, even though the plant is not a native of Wisconsin, it has been in this state for almost a century. Not all the



FIG. 10.—CITIES AND VILLAGES OF WISCONSIN IN WHICH COMMON BARBERRY BUSHES HAVE BEEN FOUND

Note the widespread occurrence of this bush.

plants came from New England, however, for we find that S. B. Lueders, a botanist, brought bushes from Germany in 1852 and planted them near Sauk City, and that John Meidam brought bushes from Holland in 1853 and planted them near Appleton. Other bushes were brought from England about 1850 and planted near Manitowoc, and still others came from Switzerland.

At the present time it is very difficult to trace the history of most of the early plantings in this state, but enough has been given to show that the barberry was introduced many years ago and that where the bushes are now found growing wild they have simply escaped from cultivation. In more recent years the nurseries sold thousands of both the green and the purple common barberries in Wisconsin for use as ornamental plants. This was stopped in 1918 when the Barberry Eradication Campaign was started.

ERADICATION OF THE BARBERRY

Early Attempts at Eradication

The harmful effect of the barberry on grain crops is not a new discovery and the eradication of this bush to save the grain has been attempted many times. About 1805, what has been called the "Barberry War" broke out in parts of Europe and particularly in Denmark. As has been said, it was about this time that the bush had found favor as a hedge to separate fields but the farmers soon learned that where it was so used they could raise an abundance of straw but no grain. That this bush was in some way responsible for the poor crops was soon recognized and many hedges were destroyed. However, as many people raised the plant for its supposed medicinal value and others used the fruit in making wine and jellies, the bushes were not all destroyed and the records tell of groups of angry farmers who armed themselves and made raids on the bushes of neighbors who had refused to destroy their barberries. One instance is told of a village judge who had some common barberries and refused to permit their destruction, although all the others in the district had been removed. For many years the farmers were unsuccessful in their efforts to eradicate these plants, but the day after the death of the judge in 1839 they armed themselves "with spades and axes" and "before evening came the bushes were spread on the earth." They were then burned "amidst song and jubilee."

During this "war," laws against the barberry were passed in parts of Germany, France, and Denmark, and laws have since been passed in other European countries. Today there are laws against the common barberry in practically all European countries and it is extremely difficult to find any of the bushes in the agricultural sections of the continent.

In the United States, laws against the barberry were enacted in Connecticut, Rhode Island, and Massachusetts between 1726 and 1766. In Connecticut and Rhode Island, these laws were renewed after a

period of years so the results must have been satisfactory. They did not exterminate the barberry, however, and today it is found growing wild very extensively throughout New England, so that its eradication would be extremely difficult, if not practically impossible.

Recent Successful Eradication

The first successful eradication campaign was carried on in Denmark. In 1903, a law was passed requiring the destruction of all harmful barberries in that country, and by 1910 practically all bushes had been destroyed. The results were striking. Previous to 1903, severe rust epidemics with heavy losses had been common but since the bushes have been destroyed there has not been a single epidemic and very little rust has been found. In most cases such rust as has been found has been traced to some barberry that had been overlooked.

The Eradication Campaign in the United States

States Pass Laws Against Growing the Barberry

American scientists, as well as farmers, had long recognized the possibility of controlling stem rust by the removal of the barberry but concerted action was not possible until the increasing frequency and destructiveness of rust epidemics throughout our northern wheat-growing states made some action imperative if wheat, and especially spring wheat, was to continue to be grown. In 1918, the United States Department of Agriculture, in cooperation with thirteen of the northern wheat-growing states, extending from Ohio and Michigan on the east to Colorado, Wyoming and Montana on the west, started a campaign to remove all harmful barberries from this territory. Laws soon were passed in all these states forbidding the propagation of common barberries and all other varieties known to carry rust.

The following is an extract from the Wisconsin State Law and is typical of the laws passed in all the states interested in this campaign:

Section 96.38. HARMFUL BARBERRIES, ERADICATION OF. (1) No person shall receive, ship, accept for shipment, transport, sell, offer for sale, give away, deliver, plant or permit to exist on his or its premises any harmful barberry, or any plant of a species that shall be designated by the department of agriculture in published regulations to be a host or carrier of a dangerous plant disease or insect pest.

(2) The state entomologist may destroy any such plant found growing in the state. If the owner shall refuse or neglect to eradicate such plants within ten days after receiving a written notice so to do, the expense of such eradication shall be certified to the town, city or village clerk and assessed, collected, and enforced against the premises upon which such expense was incurred as taxes are assessed, collected, and enforced, and shall be paid into the treasury of the state.

(3) The term "harmful barberry" shall be interpreted to consist of any species of *Berberis* or *Mahonia* susceptible to infection by *Puccinia graminis*, commonly called black stem rust of grain, but not including Japanese barberry, *B. thunbergii*.

98.48. PENALTY FOR VIOLATIONS; PROSECUTIONS. Any person violating any provision of sections 96.33 to 96.47, inclusive, or any rule or regulation promulgated under the authority of said sections, shall be fined not less than twenty-five dollars nor more than five hundred dollars for each offense.

Immense Numbers of Barberries

It was thought at first that very few barberries would be found, but four years' work has disproved this idea. Comparatively few of these



FIG. 11.—MAP SHOWING RESULTS OF FARM-TO-FARM SURVEY

The dots indicate the location of farms on which barberries were found in the 26 southern counties where the survey has been completed.

bushes were found in Montana, Wyoming and Colorado, but as we progress eastward the numbers increase rapidly, and the magnitude as well as the seriousness of the undertaking becomes apparent.

At present, Wisconsin leads all the other states in the number of bushes found and consequently in the magnitude of the work necessary to free herself from this pest. Not only are the common barberries found growing in the planted shrubbery in the cities, but many a farm boasts a beautiful bush in its front yard! In the counties in the southern part of the state which have already been surveyed (Fig. 11) there were an average of about 70 farms per county having barberries. Unfortunately this bush thrives in our climate and on many



FIG. 12.—A HEDGE OF COMMON BARBERRIES PLANTED AROUND AN ORCHARD

The hedge of common barberries spreads rust to the neighboring grain fields causing immense losses each year.

farms barberry seeds, scattered by birds and cattle, have taken root spreading the plant along the fences and into the pastures. At first the farmers thought little of the danger to their fields. Some tried to cut out the bush but where one plant was cut down a dozen grew from the broken roots and it soon became apparent that, as a weed, the barberry was as hard, if not harder to kill than the Canada thistle.

This was a new and unexpected development and one which has increased the seriousness of the problem many fold. It is evident that, had the barberries been left to spread but a few years longer, the task of eradicating them would have been insurmountable and many other-

wise valuable and productive fields would have been over-run and made valueless by this aggressive weed, as has already occurred in the New England states. What effect this would have had on the wheat and other small grains of the state is problematical.

Barberry Very Difficult to Eradicate

The barberry should be destroyed immediately, both on account of the danger to the cereals and the imminent danger of its becoming a serious and widespread weed in this state. But this is not as easy as one might wish and it is on just this account that it is so dangerous. It is a shallow-rooted plant, most of the roots lying within six inches of



FIG. 13.—THE PROPER WAY TO REMOVE BARBERRY BUSHES

Dig deep enough to get all of the roots out with the plant to prevent sprouting. Heavy canvas gloves protect the hands.

the surface of the soil but spreading to a considerable distance in all directions. Even with careful digging, these roots are seldom removed entirely but are broken off, leaving portions in the ground. These portions almost invariably sprout and produce thrifty young plants which soon replace not only the one that was removed but add a large number of new ones. By continued watchfulness and repeated digging, it is a fairly simple matter to remove a few bushes from around a house, but where there are thousands of bushes scattered over pastures and woodlots and along fence rows, it is not so easy.

The old bush can be easily removed by digging, by use of a team or tractor or a stump-pulling outfit, or by blasting. All these methods are in use, the one chosen depending on the size and number of the bushes, the character of the soil, etc., but with the greatest care some roots are always left in the soil and the spot must be revisited a second and a third time.

Experiments are under way to find the best and cheapest method of killing the barberries. Numerous chemicals have been studied and two are recommended for use. These are salt and sodium arsenite solution. The salt is used dry. About ten pounds piled in the center



FIG. 14.—SPROUTS OF THE COMMON BARBERRY IN A WISCONSIN PASTURE

The bushes were cut off two different times and each time sent up a new lot of sprouts.

of an average size bush will kill it. Sodium arsenite is made into a dilute solution containing the equivalent of about eight pounds of white arsenic (As_2O_3) per barrel of water. Two gallons of this solution poured around the base of a barberry will effectually kill an average size bush. It acts best when the ground is relatively dry and the weather warm. More detailed directions for the use of these chemicals can be found in circular 268 of the U. S. Department of Agriculture.

Present Status of the Campaign in Wisconsin—Cities and Villages Freed From Barberberries

The Barberberry Eradication Campaign has been under way in Wisconsin since April, 1918. The first move was to find and remove all dangerous bushes from the cities, parks and nurseries, for from these the bushes are carried into the country. The accompanying map (Fig. 10) shows the villages and cities where barberberries were found and removed. It should be noticed how widely the bush was distributed throughout the state.

The number of bushes found and the number of properties are given in a table on page 27.



FIG. 15.—THE COMMON BARBERRY GROWING WILD IN A PASTURE

The barberberry has escaped into pastures and woodlots; where once established it becomes a serious weed.

Country Districts Still Have Many Barberberries

When the cities and villages were fairly free of barberberries attention was directed to the country districts and at present the survey is proceeding county by county. This work was started in the southeastern corner of the state and is progressing westward and northward. It is necessary to visit and inspect every farm, for many people do not know the bush and a few are selfishly refusing to destroy their barberberries until ordered to do so by an inspector. Consequently, with the limited funds available, the work is going slowly, but it is progressing, and when a county has been gone over in this manner few or no barberberries remain.

The accompanying map of the southern portion of the state (Fig. 11) shows the territory that has been covered in this farm-to-farm survey and the approximate number and location of the farms on which barberries have been found. More exact data are given in the table on page 27.

Wild Barberries are a Serious Menace

A third phase of the campaign and one which is assuming even greater importance is that of barberries which have escaped from cultivation, a problem which has previously been mentioned. Such wild bushes already have been found in over 82 areas throughout the state and as the campaign progresses many more undoubtedly will be found. In some cases there were but one or two bushes, but in others the bushes had already spread over an area several miles in extent and the farmers were beginning to realize their destructiveness as a weed entirely apart from their effect on the grain. The aggressive character of this "weed" may be realized by the experience of one farmer in Grant county. He has a wooded pasture of about 300 acres in which the barberries had secured a firm foothold. When visited by an inspector, this farmer said he had been digging out the bushes as fast as he found time for several years and estimated that he had removed about 5,000. It was evident, though, that he was not even keeping up with the spread of the barberry. In 1920, a crew of men was employed and about 35,000 large plants, besides a very large number of small ones, were removed from this pasture. In 1922 another crew of eight men went over this pasture, carefully digging all sprouts and removing many small bushes which had been missed previously. The pasture is still far from being free of barberries, however, as many small plants still remain and more sprouts will develop. There may also be many seeds which have not yet germinated. The danger may be better realized when it is added that the original hedge from which all these wild bushes came was planted by this farmer only about thirty years ago!

Present Status of Barberry Eradication in the United States

There are thirteen states engaged in the eradication campaign. Because, in most of these states, the complete eradication of the common barberry will require from five to fifteen years at the present rate of progress, the work has been planned so that the clean area in one state will join with the clean areas in the neighboring states. For instance, North Dakota, South Dakota, and Nebraska have worked on their eastern borders, while Minnesota and Iowa have worked on their western borders thus making a continuous strip of territory from Canada to the southern edge of Nebraska and Iowa free from barberries. Likewise, Wisconsin started on the south and Illinois on the north. In 1922 Wisconsin connected with a clean area on the northern edge of Iowa and the southern edge of Minnesota, making a continuous strip of territory nearly free from barberries from Lake Michigan to South Dakota.

The plan of the work has been similar in the different states though the territory covered varies considerably in extent at present. The area covered in the farm-to-farm survey in Wisconsin is small when compared to the areas covered by some of the other states, though in actual numbers of bushes found and eradicated she is first. The very fact that very large numbers of wild barberries have been found in this state has slowed up the work tremendously. Some of the other states have also given much greater financial assistance to the work than has Wisconsin. The Minnesota legislature up to 1923, for instance, has given more than ten times the financial aid to this work that the Wisconsin authorities have been able to give.

The following table shows the number of properties on which barberries were found in each of the thirteen states, as well as the number of bushes found and removed.

TABLE III.—SHOWING THE RESULTS OBTAINED IN THE BARBERRY ERADICATION CAMPAIGN FROM APRIL 1, 1918, TO DECEMBER 31, 1922.

State	No. of properties from which bushes have been removed	Total number of barberry bushes found	Total number of barberry bushes removed
Colorado.....	1,639	24,001	23,822
Illinois.....	9,085	142,882	129,786
Indiana.....	3,923	96,284	94,004
Iowa.....	8,365	764,096	761,227
Michigan.....	6,490	265,109	221,090
Minnesota.....	4,611	778,997	776,803
Montana.....	196	9,027	8,680
Nebraska.....	3,153	88,862	88,180
North Dakota.....	731	19,438	19,438
Ohio.....	5,402	230,083	210,438
South Dakota.....	739	52,309	47,302
Wisconsin.....	7,580	3,854,155	2,788,936
Wyoming.....	78	4,140	3,841
Total.....	51,992	5,829,368	5,173,547

SUMMARY

The presence of the dangerous barberry in the vicinity of grain fields gives the black stem rust a "running start" in the spring. This has been observed many times since the barberry eradication campaign was started in Wisconsin in 1918.

The black stem rust fungus overwinters on grain stubble and on many grasses. In the spring, in May or early June, when the barberry leaves are coming out, spores are carried by the wind from the stubble, and rust starts on the barberry. Within a week or ten days it develops on grains and grasses and spreads like "wild fire" if the weather is warm and moist. Spores from stubble will not infect young grain nor will those from barberry spread rust to barberry. Therefore, the removal of the barberry takes out an important link in the chain of development and so slows up the early spring start of the rust that most grains are able to ripen a crop without danger from a rust epidemic.

The barberry is a native of Asia but was brought to Europe at an early date and came to this country along with the early settlers. It was widely planted as a quick-growing, ornamental shrub whose yellow roots were thought to have medicinal value.

In common with 12 other states in the upper Mississippi valley region, Wisconsin has passed a law condemning the dangerous barberry. The state entomologist or his deputies are empowered to inspect any property they think necessary and to order removed or to remove at owner's expense any dangerous barberry. Fortunately the Japanese barberry does not harbor rust and need not be removed.